Pathfinder Program

Presented at the
NASA Reusable Launch Vehicle Technology Exposition
June 22, 2000

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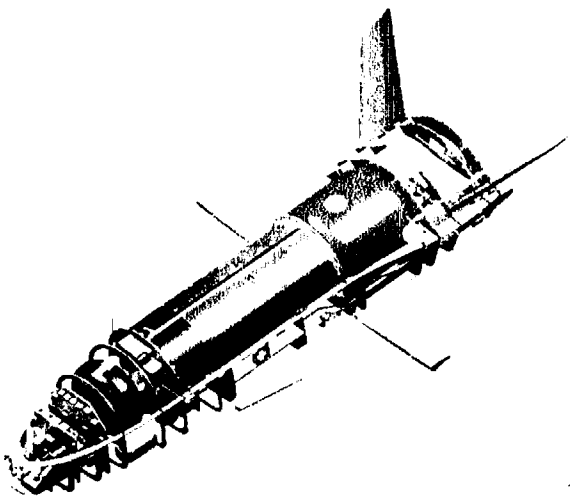
Program Overview

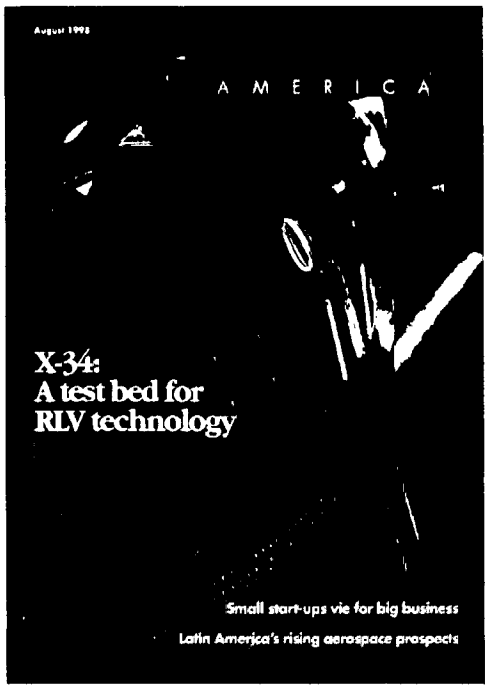
- **RLV Goal: to Significantly Reduce the Cost of Access to Space**

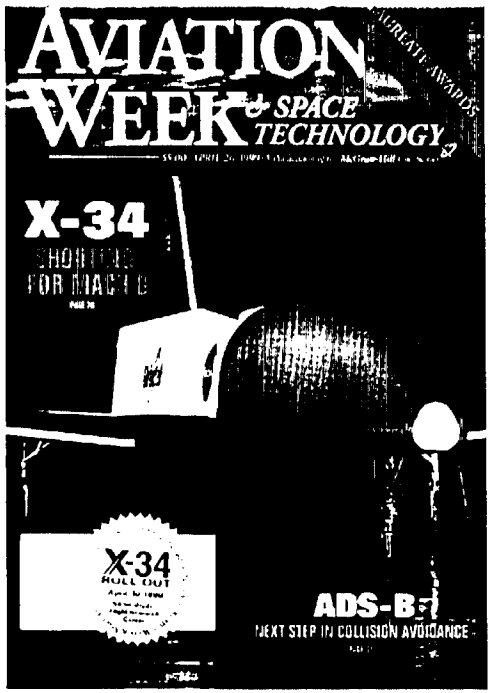
- **X-34 Project Objectives**
  - Test Bed Vehicle for Demonstrating Key Reusable Launch Vehicle (RLV) Operations and Technologies
  - Focus Areas
    - **Investigation of New Methods for Low-Cost Operations**
    - **New RLV Technologies Embedded in Vehicle Design**
    - **Demonstration of Hosted RLV and Hypersonic Experiments**

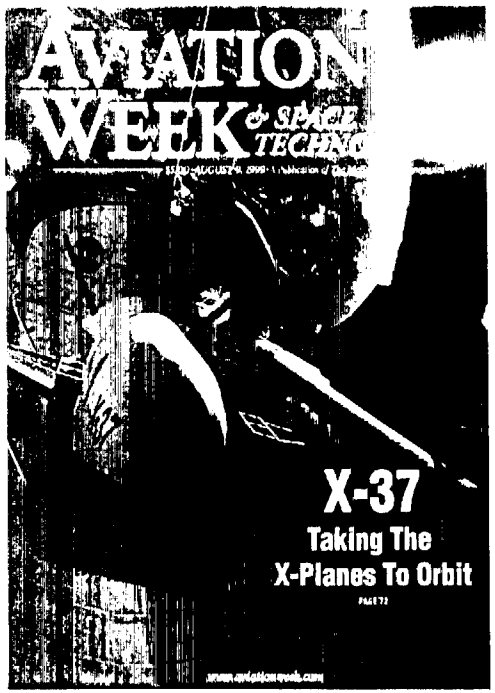
- **X-37 Project Objectives**
  - Test Bed Vehicle for Demonstrating RLV In-Space and Re-Entry Technologies and Flight Experiments
  - Focus Areas
    - **Investigation of New Methods for Design and Manufacturing**
    - **New RLV Technologies Embedded in Vehicle Design**
    - **Demonstration of Hosted RLV and Re-Entry Experiments**



High Visibility Flight Projects

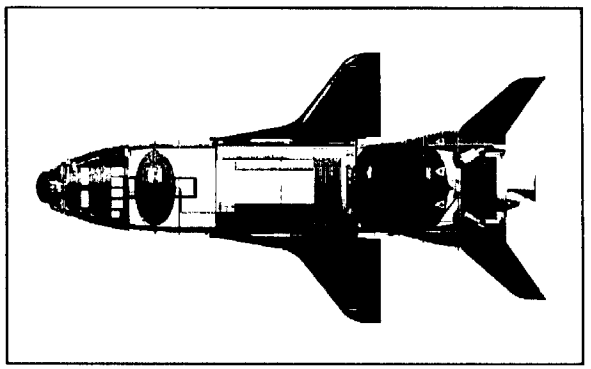


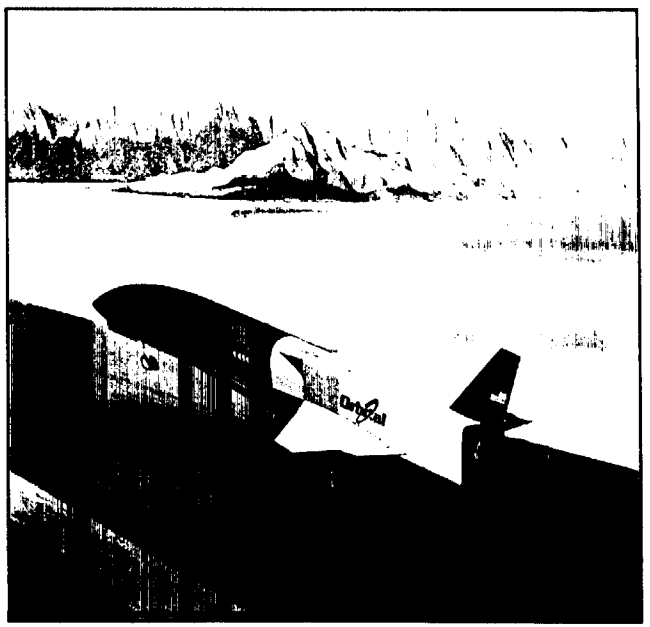




Pathfinder Flight Experiments

- **Flight Experiments**
  - Flown on X-34:
    - **GAMMA-TITANIUM ALUMINUM-BASED TPS (ALENIA AEROSPACE)**
    - **ADVANCED C/SIC TPS (ESA-DAIMLER-BENZ)**
    - **MECHANICALLY ATTACHED FLEXIBLE TPS (BOEING)**
    - **ENCAPSULATED WATERPROOF 2500F CMC TPS (MDA [Now BOEING])**
    - **FLIGHT TEST DETAILED SPECIMENS IN CERTIFIED HOLDER (MDA [Now BOEING])**
    - **ACTIVE DAMAGE INTERROGATION HEALTH MONITORING SYSTEM (MDA [Now BOEING])**
    - **ACOUSTIC EMISSION HEALTH MONITORING SYSTEM (BOEING)**
    - **AUTONOMOUS ABORT LANDINGS (DRAPER LAB)**
    - **INTEGRATED VEHICLE HEALTH MANAGEMENT (IVHM) (NASA AMES)**
    - **COMPOSITE LOX TANK (LOCKHEED-MARTIN)**
  - 40 Embedded or Carry-On Experiments Baselined for X-37

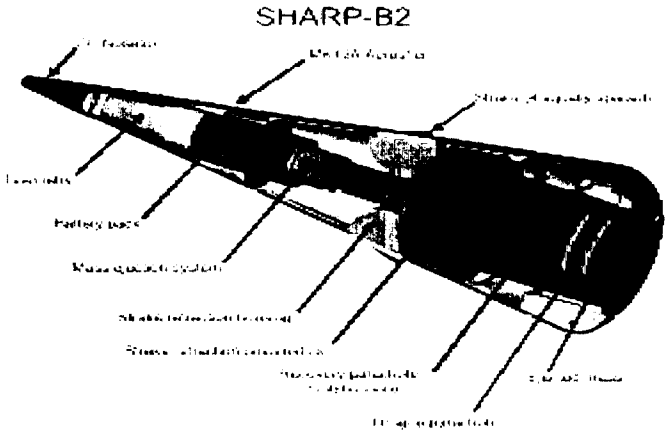


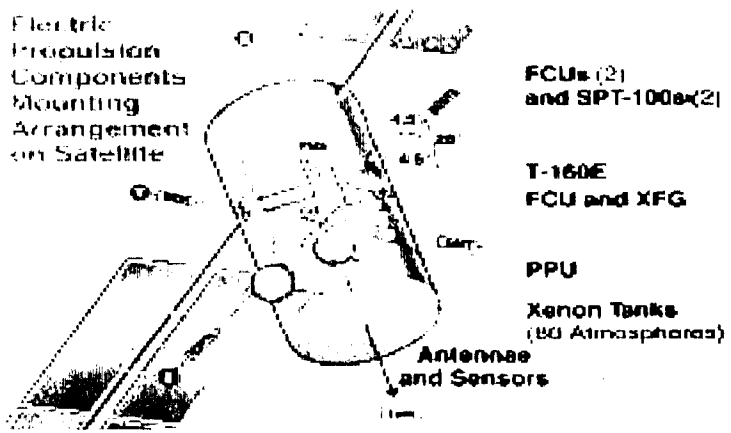


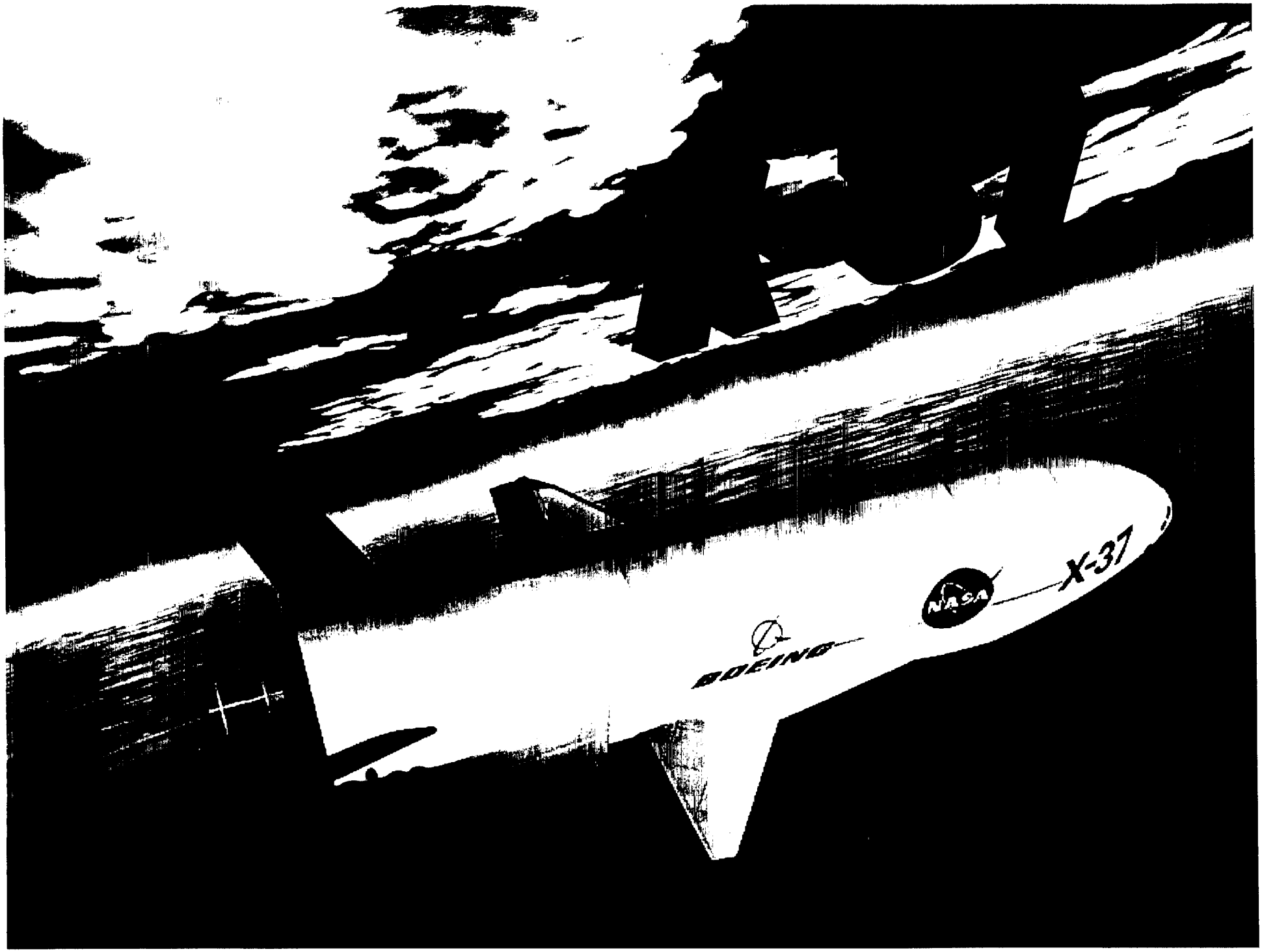
Pathfinder Flight Experiments (cont'd.)

Flight Experiments

- Other Flight Experiments:
  - **REDUCED COST SMALL PAYLOAD TECHNOLOGIES (AERO-ASTRO)**
    - Deployed from the Space Shuttle
  - **CERAMICS FOR SHARP LEADING EDGES (NASA AMES)**
    - Flown on a Minuteman III
  - **ProSEDS (NASA MSFC)**
    - Flown as a secondary payload on a Delta II upper stage
  - **HALL EFFECT THRUSTER (NASA GRC)**
    - Instrumentation flown on a Russian communications satellite
  - **CRYOGENIC PROPELLANT GAUGE (NASA GRC)**
    - Flown on the USAF Solar Orbit Transfer Vehicle Space Experiment

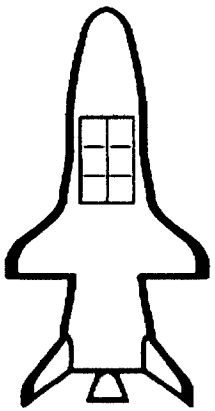




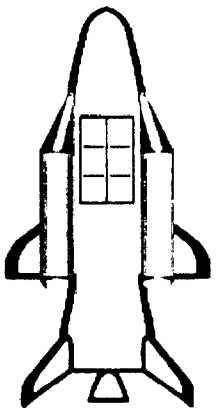

BOEING
NASA
X-37

X-37 Configuration Modification Options

Baseline

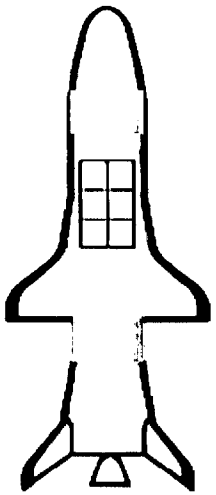


Increased Propellant

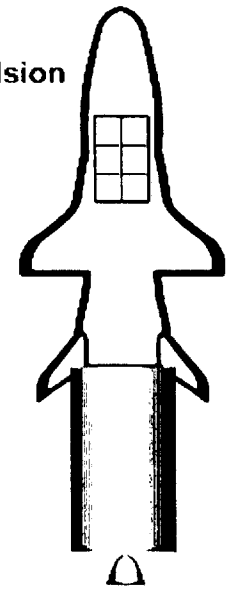


Drop Tanks

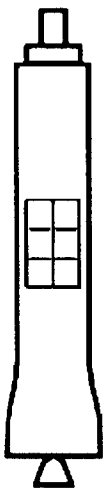
Fuselage Plugs



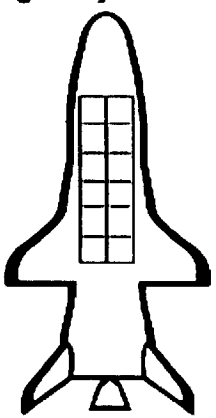
Auxiliary Propulsion



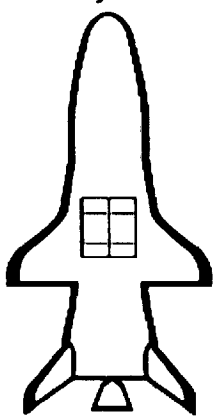
On-Orbit Only



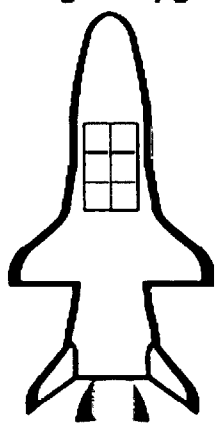
Large Payload Bay



Small Payload Bay



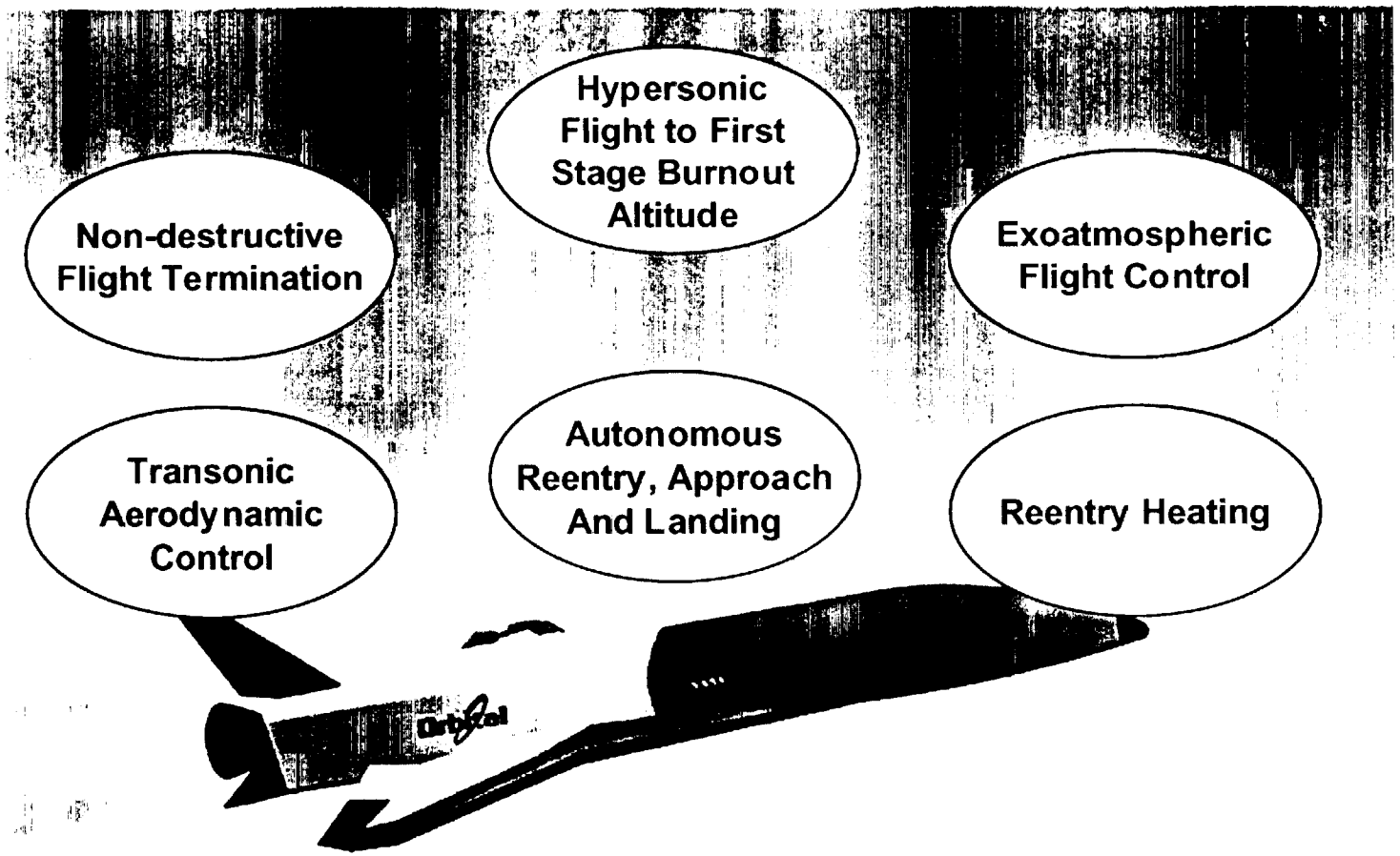
Main Engine Upgrades



Expansion-Deflection Nozzle


SX4

Flight Testing for a Multistage Reusable System



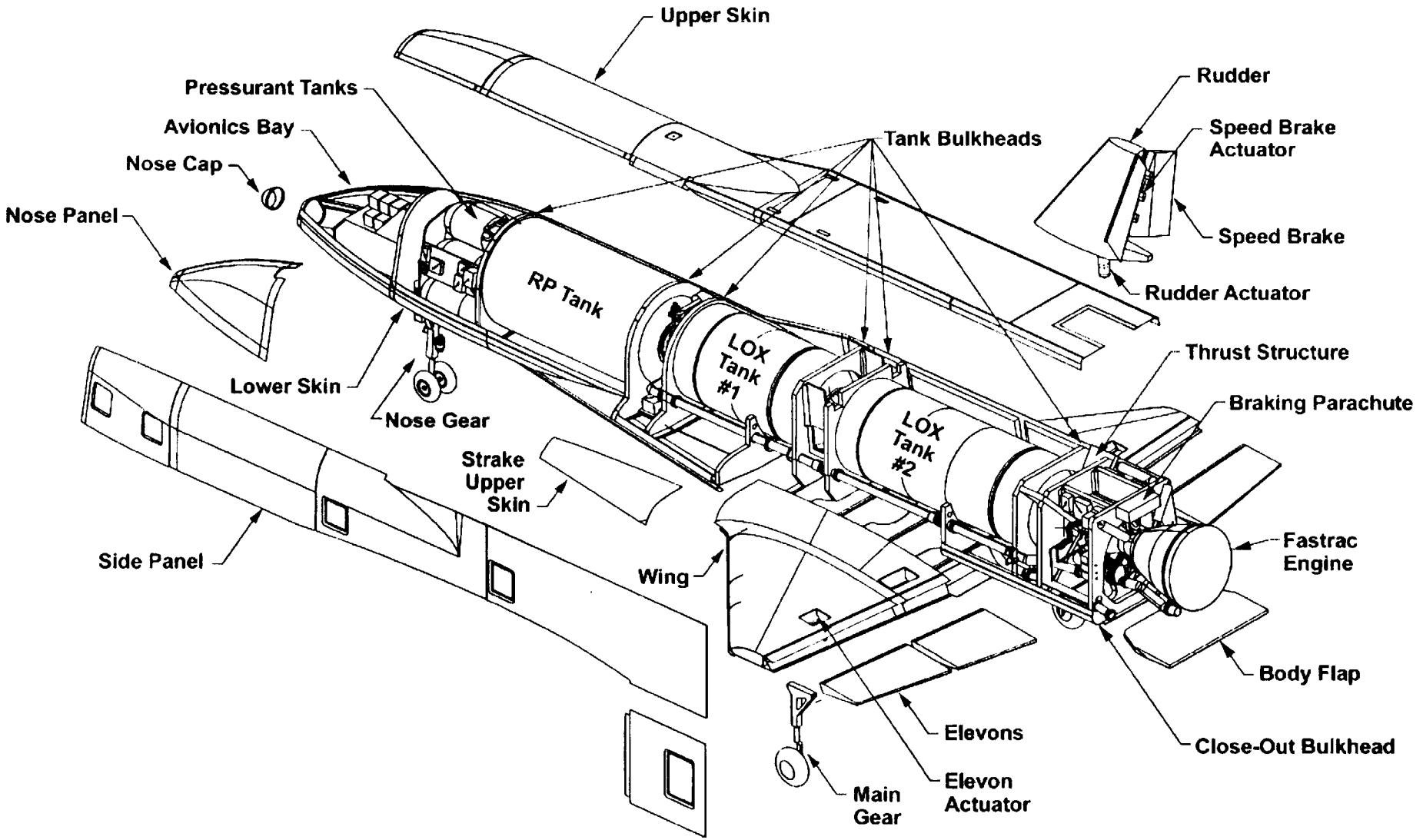
The X-34 Flight Regime Duplicates the Environment and Mission Characteristics Of a Reusable First Stage

X-34 Vehicle Description

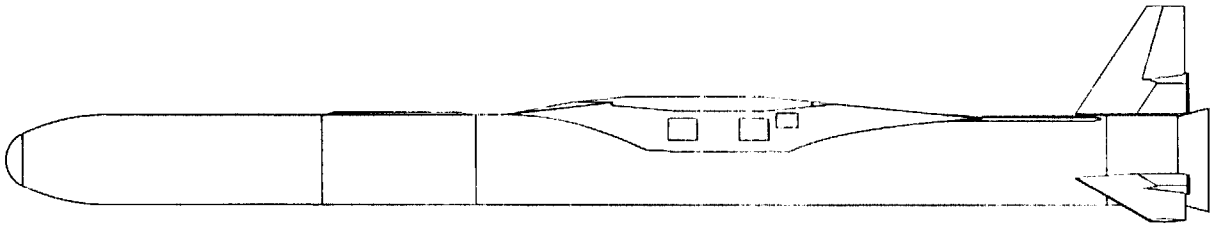
- **Single Stage, Sub-Orbital, Fully Reusable, Unmanned Testbed Aerospace Plane**
- **Three airframes: A-1A, A-2, A-3**
  - A-1A is unpowered, A-2 and A-3 are powered
- **Vehicle Characteristics**
  - Length 58.3ft
  - Wing Span 27.7 ft
  - Gross Weight *45,488 lbs.
  - Propellant *30,350 lbs.
  - Payload 450 lbs.
  - Operating Weight Empty* 15,138 lbs.

    *Target Weight
- **Airframe**
  - Composite structure and skin
  - One piece wing with center carry through structure
  - Elevon control surfaces
  - All-flying vertical tail
  - Body flap for pitch axis trim
- **Avionics**
  - Single string with exception of dual string flight termination system

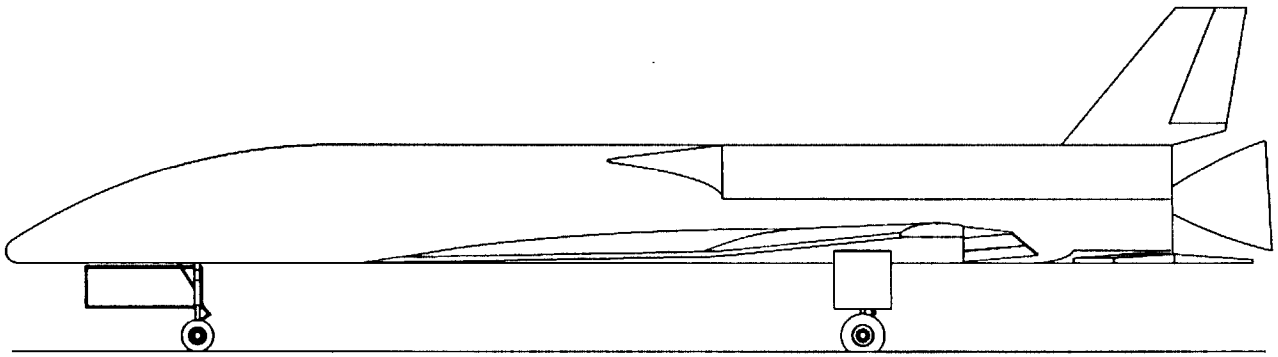
X-34 Expanded View



Vehicle Size Comparison

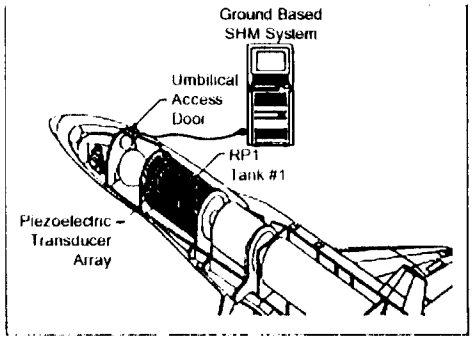


Pegasus XL

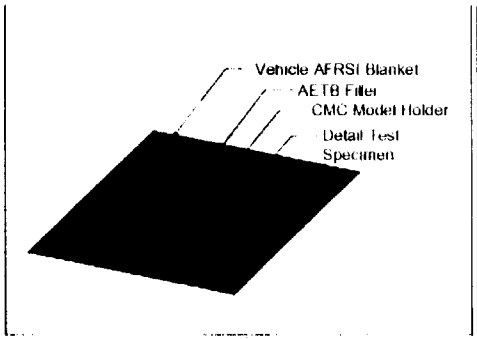


X-34 Technology Testbed Vehicle

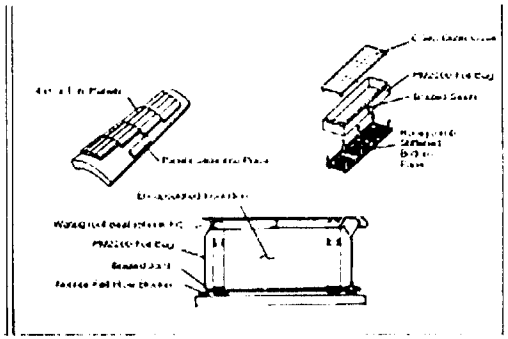
X-34 Experiment Status



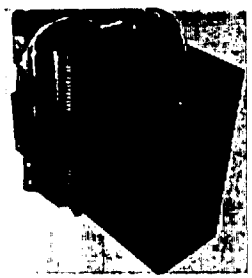
Integrated Structural Health Monitoring System for the X-34 RP1 Tank (Boeing, St. Louis).



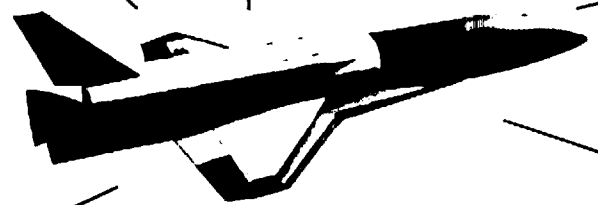
Detail Test Specimen Model Holder (Boeing, Huntington Beach).

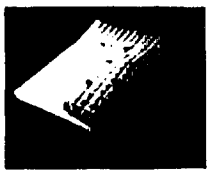


CMC Encapsulated TPS Assembly (Boeing, Huntington Beach).

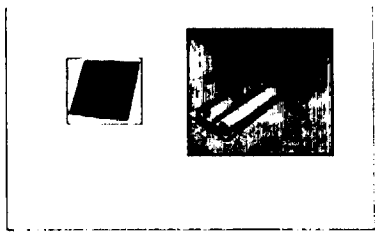


Acoustic Emission Health Monitoring System (Boeing, Seattle).

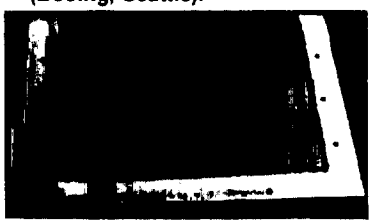




IFI Blanket
TiAl Based TPS (Alenia, Italy)

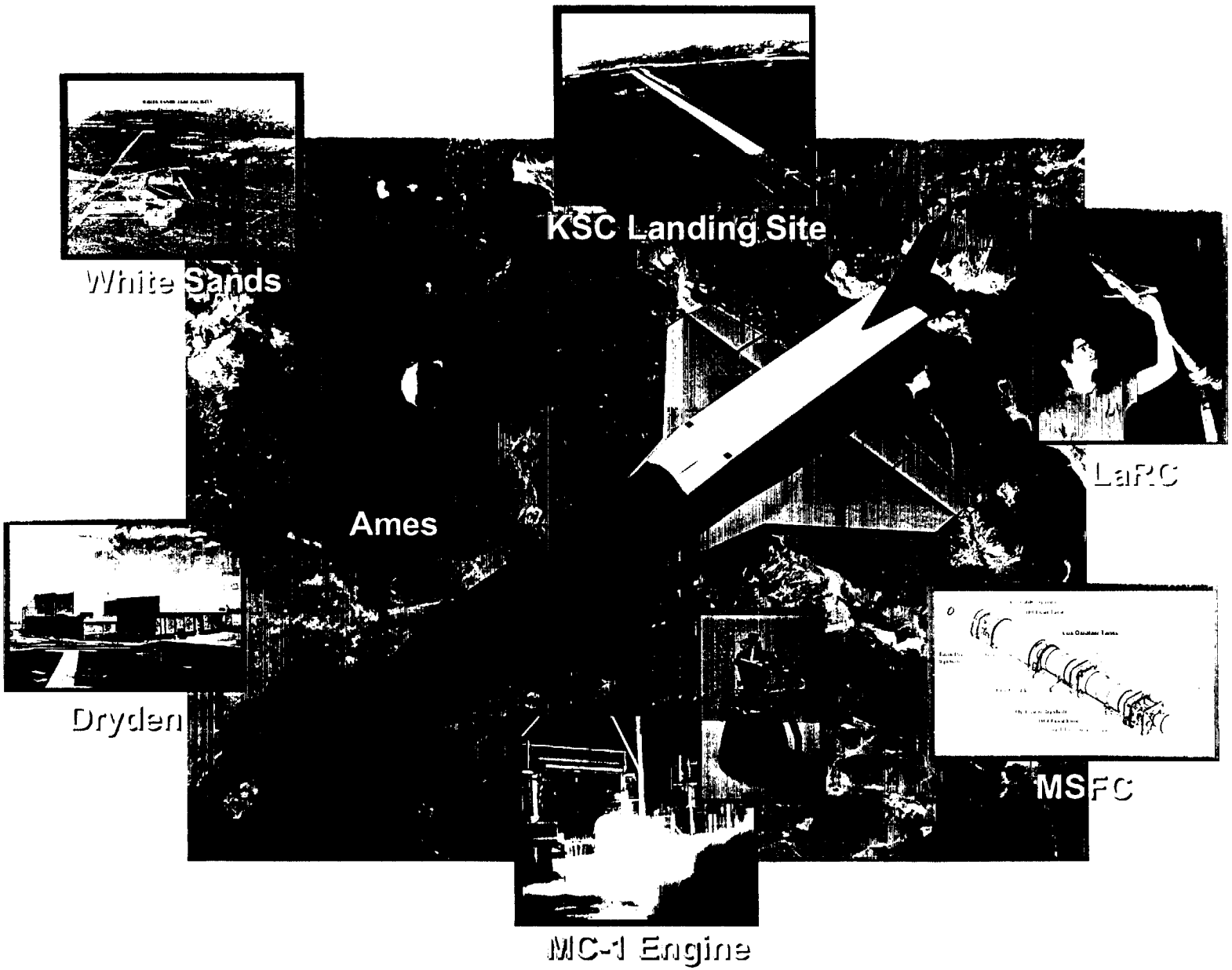


Advanced C/SiC Based TPS (Daimler Benz, Germany).



Mechanically Attached Thermal Protection System (Boeing, Seattle).

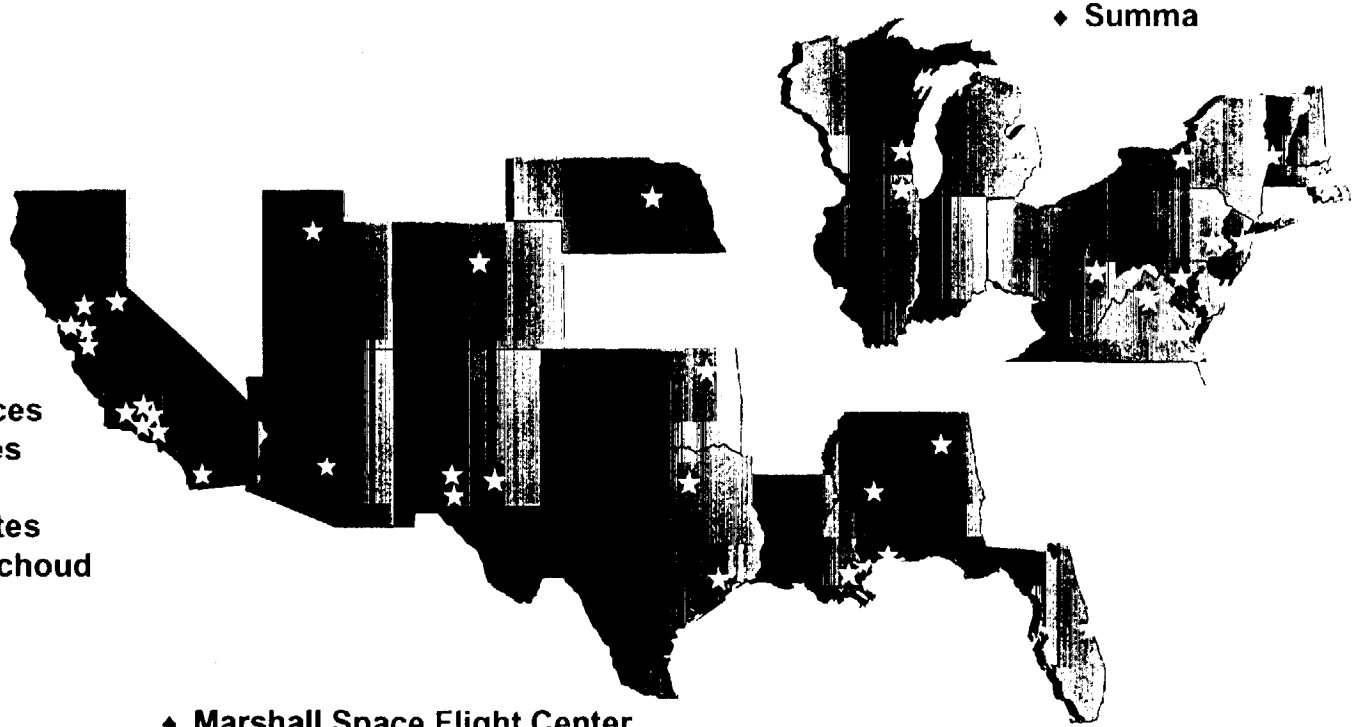
Government Participation



Government and Industry Participants

- AlliedSignal Aerospace
- The C. S. Draper Labs
- Oceaneering Space Systems
- Vermont Composites

- Litton
- OR Computers
- AP Precision Hydraulics
- Summa



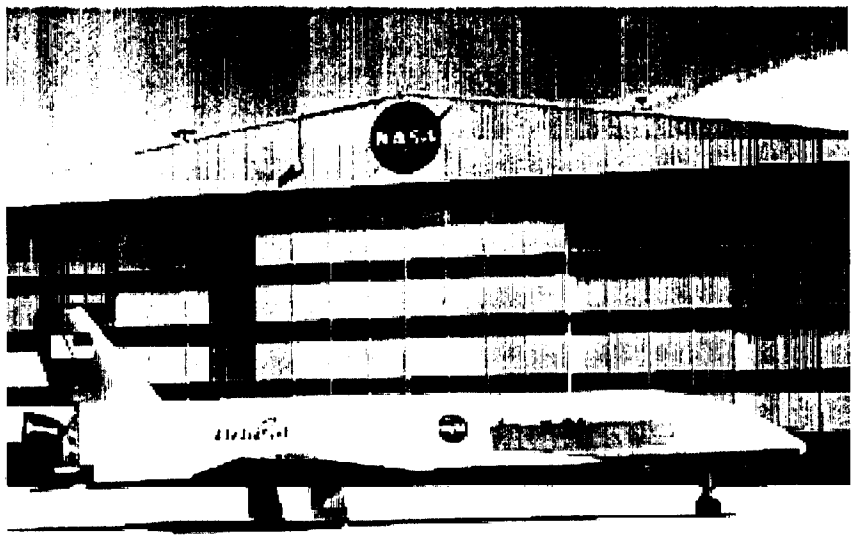
- Aurora Flight Sciences
- R-Cubed Composites
- Spincraft
- Advanced Composites
- Lockheed Martin-Michoud

- Marshall Space Flight Center
- Ames Research Center
- Langley Research Center
- Dryden Flight Research Center
- Johnson Space Center
- Holloman Air Force Base

- White Sands Test Facility
- Edwards AFB
- White Sands Missile Range
- Kennedy Space Center
- Stennis Space Center

X-34 Project Status

- **Restructuring effort underway**
  - Possible increase in ground testing for engine and vehicle, avionics mods, and new propulsion test article
  - Focused to support 2nd Gen Program
- **A-1A unpowered vehicle complete and on the runway at Edwards AFB**
  - Series of captive-carry flights and high-speed tow tests underway
- **A-2 powered vehicle complete and undergoing tests at Orbital's Dulles facility**
- **A-3 airframe essentially complete at Orbital's Dulles facility**
- **MC-1 (formally Fastrac) engine testing continuing at Rocketdyne's SSFL in Calif.**
  - 45 hot-fire tests already completed at SSC



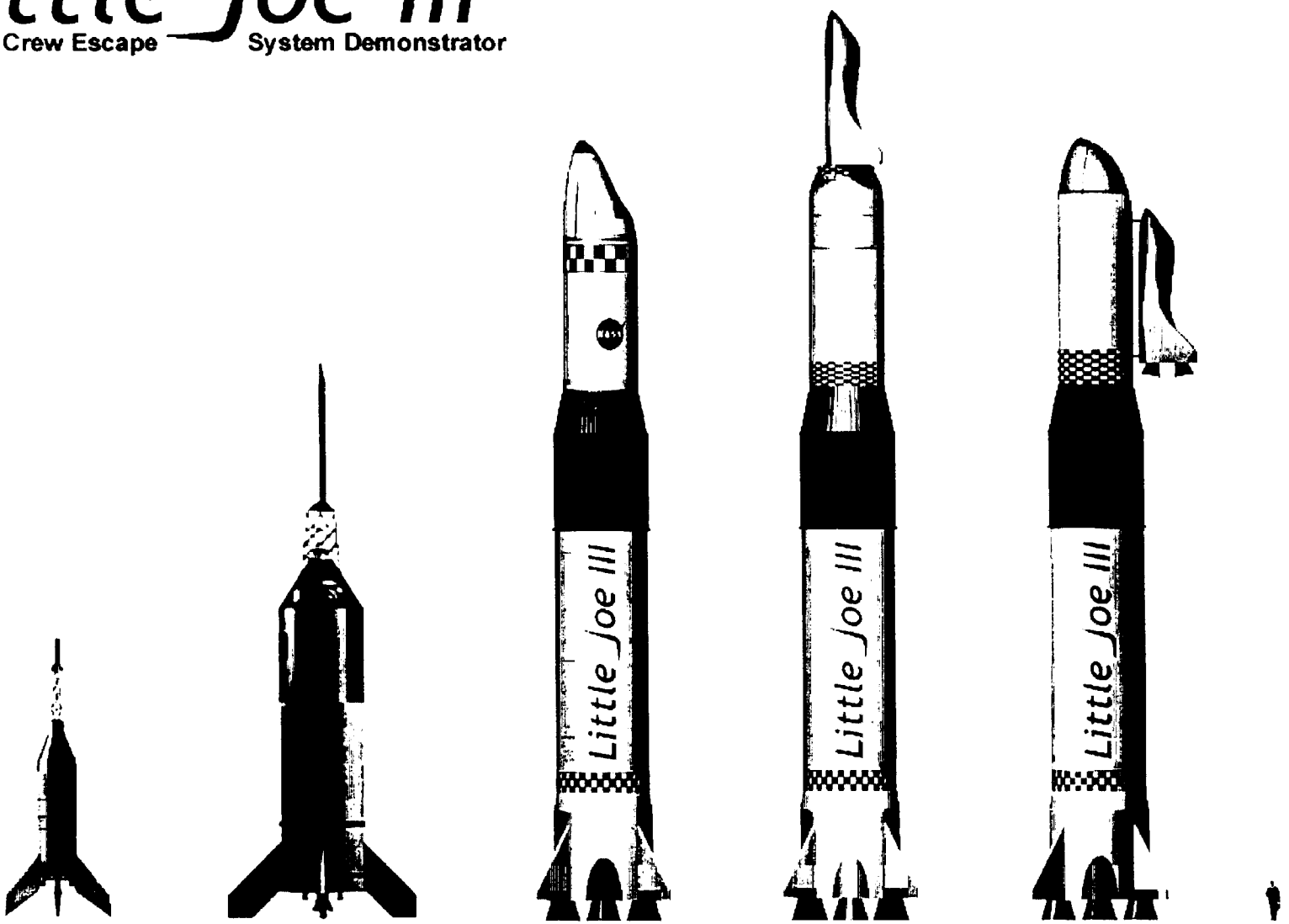
X-34 Captive Carry Flight

PATH FINDER

NASA

Little Joe III

Crew Escape System Demonstrator



Little Joe Little Joe II

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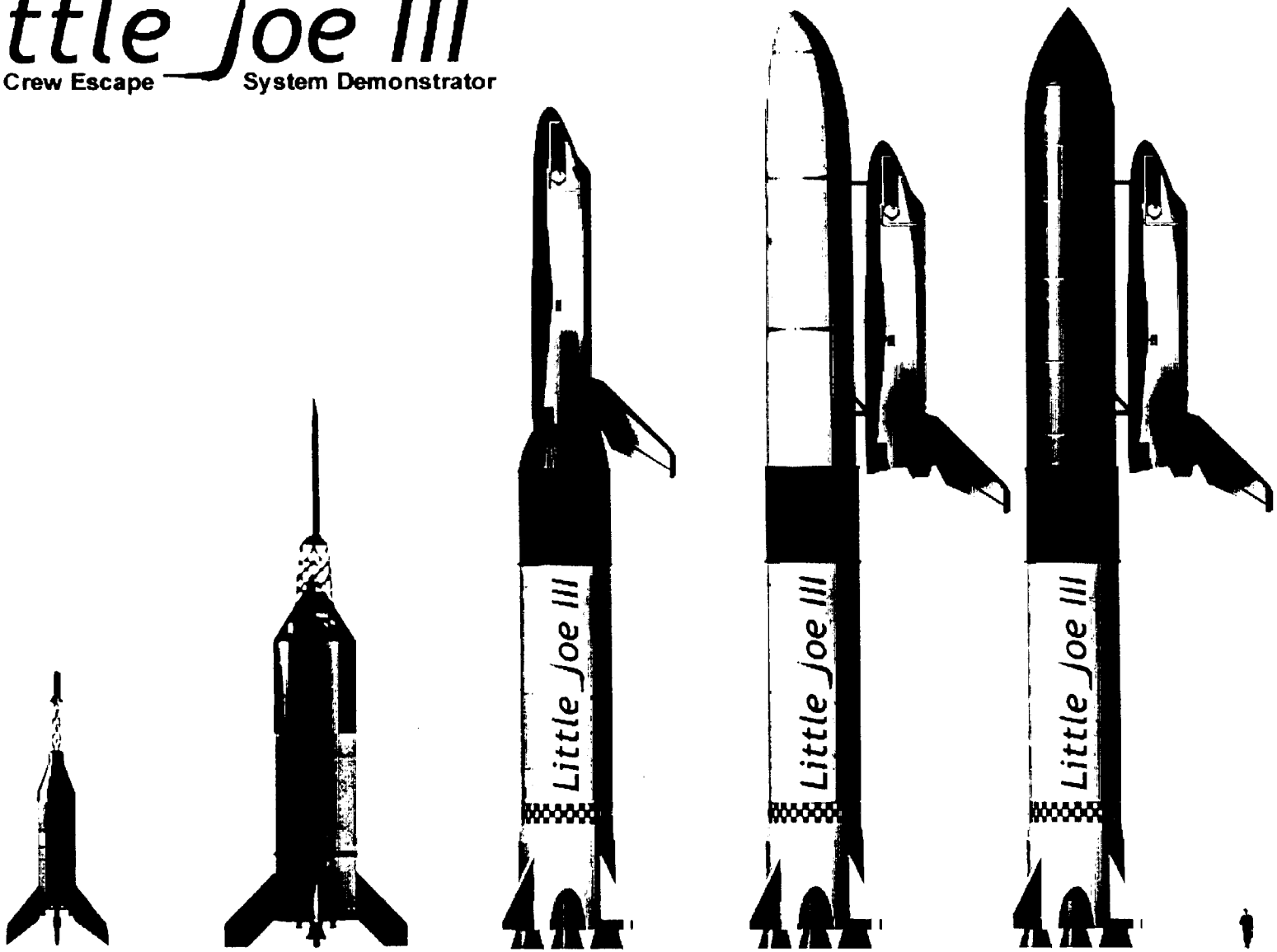
PATH FINDER

NASA

Little Joe III

Crew Escape System Demonstrator



Little Joe

Little Joe II

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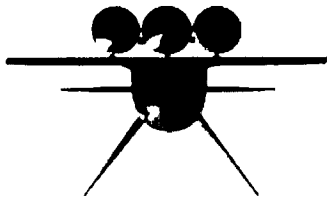
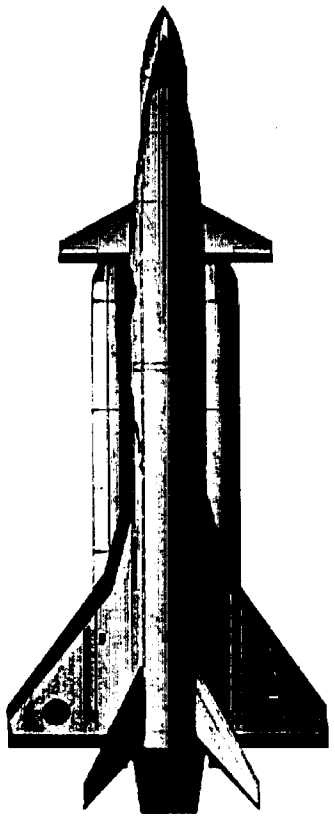
PATH FINDER

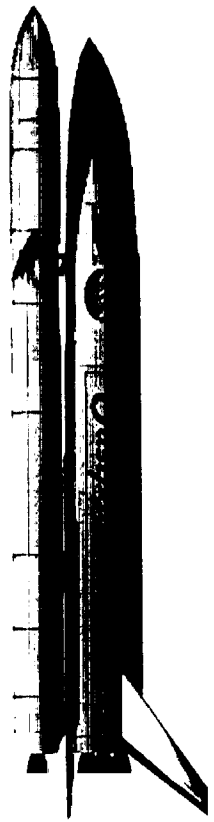
NASA



Fastpac

ISS Fast Package Delivery System

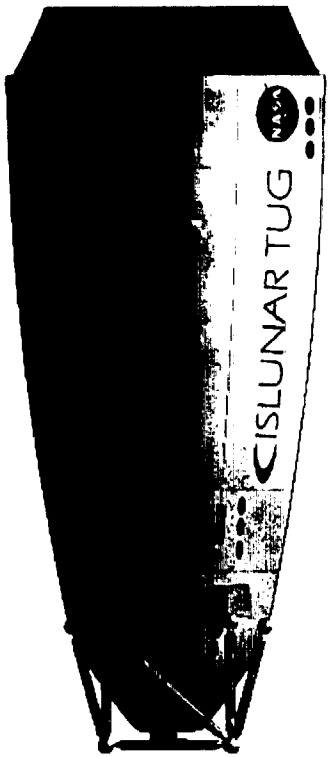


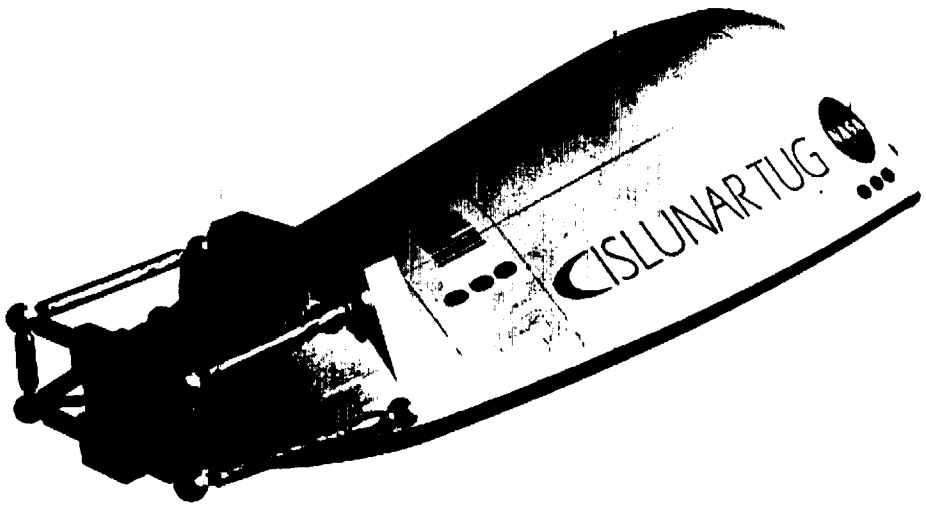


PATH FINDER

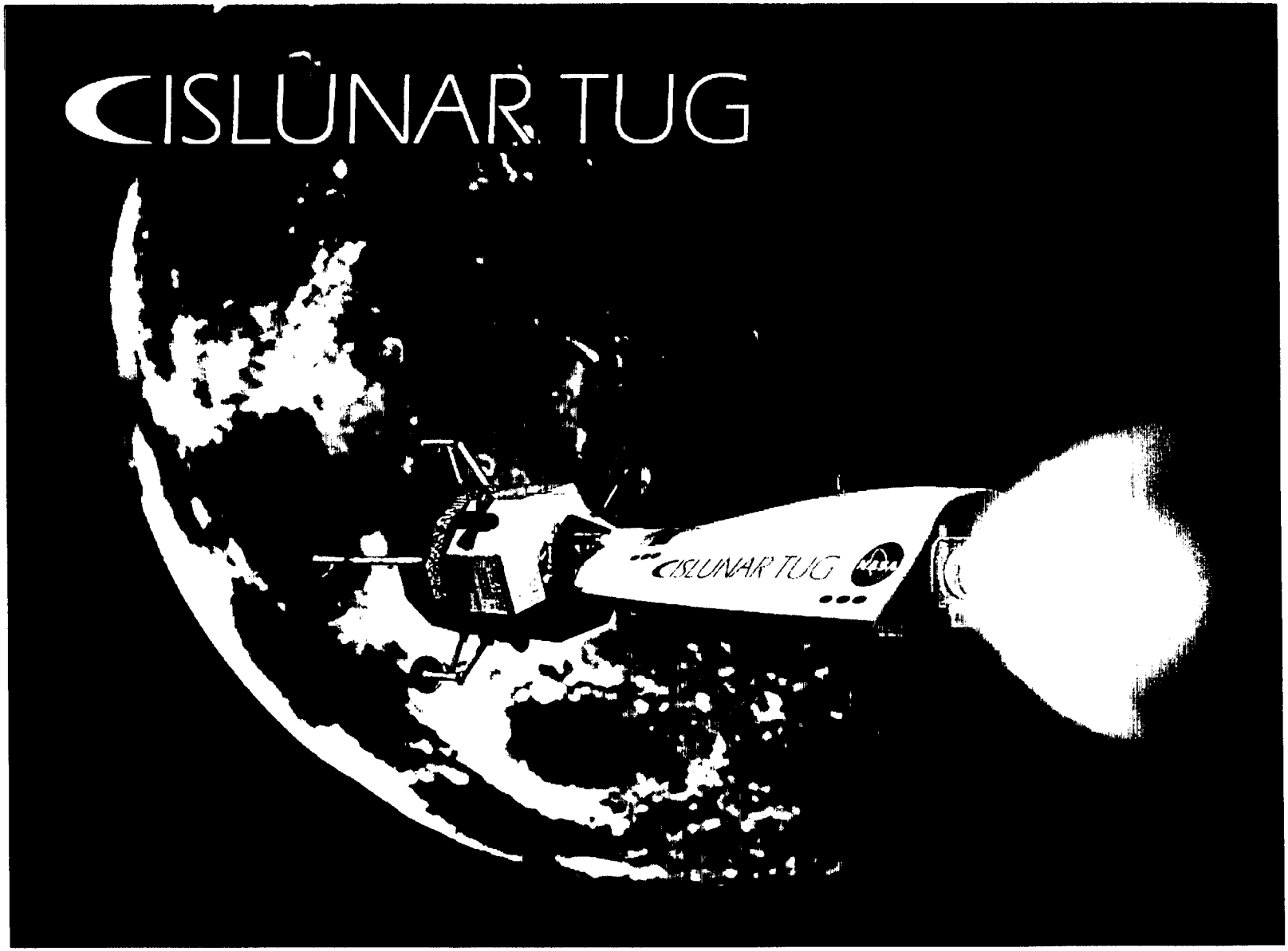
NASA

CISLUNAR TUG





Cislunar Tug With Notional Lunar Lander



Summary

- Pathfinder vehicles flight test key technologies for future low cost Reusable Launch Vehicles (RLV) quickly and inexpensively